Survey of Red Sea Urchin Populations in the Larsen Harbour and Kingkown Inlet Areas, Banks Island, British Columbia, 1997

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SURVEY OF RED SEA URCHIN POPULATIONS IN THE LARSEN HARBOUR AND KINGKOWN INLET AREAS, BANKS ISLAND, BRITISH COLUMBIA, 1997

by

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ABSTRACT

Bureau, D., A. Campbell, and W. C. Hajas. 2000. Survey of red sea urchin populations in the Larsen Harbour and Kingkown Inlet areas, Banks Island, British Columbia, 1997. Can. Manuscr. Rep. Fish. Aquat. Sci. 2551: 19 p.

A survey of red sea urchin populations in the Larsen Harbour and Kingkown Inlet areas, Banks Island, parts of Pacific Fishery Management (PFM) Area 5, was conducted in July and August 1997. A total of 57 randomly placed transects were surveyed by SCUBA divers. Densities and biomass were estimated on a per PFM sub-area basis. Estimated mean density ranged from 0.60 to 3.44 urchins per m^2, overall mean density was 2.23 urchins per m^2. Estimated mean biomass ranged from 186.0 to 1088.6g per m^2 and overall mean biomass was 743.9g per m^2. Overall, 16.4% of the total urchins measured were ≤50mm test diameter (TD) whereas 47.8% were of legal size (≥100mm TD) for the commercial fishery.

RÉSUMÉ

Bureau, D., A. Campbell, and W. C. Hajas. 2000. Survey of red sea urchin populations in the Larsen Harbour and Kingkown Inlet areas, Banks Island, British Columbia, 1997. Can. Manuscr. Rep. Fish. Aquat. Sci. 2551: 19 p.

Un relevé des populations d'oursins rouges des régions du havre Larsen et du bras Kingkown, île Banks, qui font partie du secteur d'exploitation 5, a été réalisé en juillet et août 1997. Au total, des plongeurs ont fait des observations sur 57 transects établis au hasard. Les densités et la biomasse ont été estimées à l'échelle du sous-secteur. La densité moyenne estimée allait de 0,60 à 3,44 oursins au m^2; la densité moyenne globale était de 2,23 oursins au m^2. La biomasse moyenne estimée allait de 186,0 à 1088,6 g au m^2, et la biomasse moyenne globale était de 743,9 g au m^2.Dans l'ensemble, 16,4 % du total des oursins mesurés avaient un diamètre du test (DT) de ≤50 mm, tandis que 47,8 % étaient de taille légale (≥100 mm DT) pour la pêche commerciale.

INTRODUCTION

Red sea urchin (*Strongylocentrotus franciscanus*) distribution in North America ranges from the southern tip of Baja California to Alaska (Kato and Schroeter 1985). In British Columbia (BC) the red sea urchin is found in shallow rocky subtidal habitats throughout the coast (Bernard 1977). Red sea urchins are commercially harvested for their roe, which is sold in Japan. Coastal First Nations communities harvest sea urchins as a food fishery. The commercial red sea urchin fishery started in the early 1970's and total landed value in 1997/98 was $ 14 million (Campbell et al. 1999a), making the red sea urchin fishery one of the most valuable shellfish fisheries in BC.

The commercial red sea urchin fishery history and management are described in Campbell and Harbo (1991) and Campbell et al. (1999a). Current management approaches include a minimum harvest size of 100mm test diameter (TD), a coast-wide quota, individual vessel quotas and limited licence entry. Quota calculations are based on estimates of urchin density from field surveys, and estimates of urchin bed areas. Density estimates are therefore essential to the assessment and management of the red sea urchin fishery.

Red sea urchin population surveys are a joint effort between the Pacific Urchin Harvesters Association (PUHA), First Nations and Fisheries and Oceans Canada (DFO). They have been conducted in BC since 1993 in an effort to better understand urchin abundance, distribution and biology along the BC coast. The results of 1993 and 1994 surveys in the North Coast have been published (Jamieson et al. 1998a; 1998b; 1998c; 1998d). Results from earlier red sea urchin population surveys, conducted during the 1970's and 1980's in the South Coast, were reported by Adkins et al. (1981), Breen et al. (1976; 1978) and Sloan et al. (1987).

Fishery managers requested that red sea urchin surveys be conducted to update density and biomass estimates to help determine quotas. The Larsen Harbour and Kingkown Inlet areas [parts of Pacific Fishery Management (PFM) Area 5], at the north end of Banks Island, were selected for survey (Figure 1 and Figure 2) through discussion between DFO and PUHA. The objective of this survey was to estimate current red sea urchin biomass in the area to help determine fishery quotas. Since biomass estimates, used for quota determination, are calculated on a PFM sub-area basis for management purposes (Campbell et al. 1999b), the results are presented on a PFM sub-area basis. Detailed survey results are presented here. Biomass estimates and quota recommendations for each PFM sub-area surveyed here were presented in Campbell et al. (1999b).

METHODS

SURVEY AREA AND TRANSECT LAYOUT

Survey efforts were concentrated in the Larsen Harbour and Kingkown Inlet areas at the North end of Banks Island. The Kingkown Inlet area, closed to fishing between 1996 and 1998, was considered for reopening to commercial fishing and selected for survey. The survey of the

area in 1997 served to establish quotas for the re-opening of the area for the 1998/1999 fishing season. The survey was in part explorative since this was the first survey of red sea urchin populations in this area. Transects locations were selected and plotted on a marine chart prior to the survey to avoid biases in the field. The survey was divided in two sections: shoreline and islands. The number of transects assigned to each section was proportional to the surface area of water between 0 and 10m below chart datum (BCD) of each section over the total surface area of water between 0 and 10m BCD. Surface area of water between 0 and 10m BCD was estimated using the Compugrid GIS system after digitizing the survey areas.

Transect layout along the shoreline was done by systematically placing transects along shore with a random starting point. Areas of sandy substrate were excluded from the survey area. Total shoreline length (TSL) of the survey areas was measured off marine charts using a digital curvimeter. Position of the first transect was determined randomly, subsequent transects were then spaced evenly along the shoreline. Distance between transects was TSL/n where n is the number of transects along the shoreline. Since fluctuations in urchin density are unlikely to match the spacing of the transects, the systematic sample may therefore be treated as a random sample of transects (Jamieson and Schwarz 1998).

Transects around islands were assigned by randomly choosing islands and then randomly assigning a transect compass bearing to determine the position and direction of the transects off an island.

SURVEY LOGISTICS

The survey was conducted between July 29 and August 4, 1997, on the "King Clam", a commercial red sea urchin fishing vessel. The north end of Banks Island, Larsen Harbour and the Borrowman Group were surveyed first. Kingkown Inlet was then surveyed.

DIVE SURVEY METHODS

Leadline transects were laid perpendicular to shore from the boat. Transects were laid out from shallow water to a depth of 15m and thus transect length was dependent on the slope of the substrate. A float was attached to the deep end of each transect. A 2-diver team surveyed each transect from deep to shallow, one diver measuring urchins while the other recorded data. A one meter squared ($1m^2$) quadrat was placed on the bottom beside the transect and the test diameter (TD) of each urchin present was measured to the nearest mm with callipers. The depth, substrate type, types of algae and number of green sea urchins (*Strongylocentrotus droebachiensis*) present in the quadrat were also recorded. The quadrat was then moved 2m forward along the transect and the process was repeated, so that every second meter on the transect was surveyed. In cases where the substrate was sand and no urchins were found at the deep end of transects, observations of depth, substrate and algae were recorded only every 20m to minimize dive time. Skipped quadrats were assigned zero values for urchin counts before data were analysed. Once urchins were encountered, sampling was conducted every 2m until the intertidal zone or the surface was reached. On long transects with large numbers of urchins, measurements of test diameters were recorded in only a portion of the quadrats surveyed (usually half). The number of urchins measured on a transect could therefore be smaller than the number of urchins counted.

ESTIMATION OF DENSITY AND BIOMASS

Density and biomass were estimated for urchins of 2 size groups, a) all sizes and, b) for urchins of legal size for the commercial fishery (≥100mm TD). Estimates of mean density and biomass, per PFM sub-area, were calculated using the following equations.

Density estimates (d_{ts}) in numbers/m^2 for each transect (t) and size group (s) were calculated as:

$$d_{ts} = \frac{N_{ct}}{a_t} * \frac{N_{mts}}{N_{mt}}$$

where N_{ct} is the total number of urchins counted on transect t, N_{mts} is the number of urchins measured in size group s on transect t, N_{mt} is the total number of urchins measured on transect t, and a_t is the surface area of all quadrats surveyed on the transect t. Here a_t is equal to the number of all quadrats surveyed on the transect since each quadrat had a surface area of 1m^2.

Overall mean density ($\overline{d}_s$) for a PFM sub-area for urchins of size group s was estimated as:

$$\overline{d_s} = \frac{\sum_t (d_{ts} * L_t)}{\sum_t L_t}$$

where L_t is the length of transect t (Campbell et al. 1999b).

The standard error (s_d) of estimated mean density was calculated as:

$$s_d = \sqrt{1 - \frac{n}{T}} * \sqrt{\frac{\sum_t (d_{ts} * L_t - \overline{d}_s * L_t)^2}{n * (n-1) * \overline{L}^2}}$$

where n is the number of transects surveyed, T is the total possible number of transects that can be sampled in a surveyed PFM sub-area and mean transect length ($\overline{L}$) was calculated as:

$$\overline{L} = \frac{\sum_t L_t}{n}$$

from Campbell et al. (1999b). The expression $\sqrt{(1-(n/T))}$ was approximately equal to 1 since n was much smaller than T.

To calculate biomass, the weight of all urchins measured was calculated using the relationship between urchin weight (*W*) in grams and test diameter (*TD*) in millimetres (Campbell et al. 1999b; 2000).

$$W = 0.0012659 * TD^{2.7068} \quad n= 167, r^2=0.960$$

Biomass density (b_{ts} in g/m^2) of urchins of size group *s*, on a transect *t*, was estimated using a simplified form of the formula used in previous papers (Campbell et al. 2000). The formula was modified by Campbell et al. (1999b) to simplify computations:

$$b_{ts} = \frac{N_{ct}}{N_{mt}} * \frac{\sum W_{ts}}{a_t}$$

where ΣW_{ts} is the sum of the weights of urchins measured in size group *s* on transect *t* and a_t is the surface area of quadrats surveyed on the transect *t*.

Overall estimated mean biomass ($\overline{b_s}$) per surface area (g/m^2) was calculated for each PFM sub-area as (Campbell et al. 1999b):

$$\overline{b_s} = \frac{\sum_t (b_{ts} * L_t)}{\sum_t L_t}$$

The standard error of estimated mean biomass was calculated using the same formula used for standard errors of density but where d_{ts} and $\overline{d}_s$ were substituted for b_{ts} and $\overline{b}_s$, respectively.

Recruitment estimates for the red sea urchin in BC have generally been expressed as the proportion of total red sea urchins measured that were ≤50mm TD (Adkins et al. 1981; Breen et al. 1976; 1978; Jamieson et al. 1998b; 1998c; 1998d; Sloan et al. 1987). We used the same size for comparison purposes.

RESULTS

SURVEY LOGISTICS

A total of 57 transects were surveyed (Table 1, Figure 1 and Figure 2). A few of the scheduled transects could not be surveyed due to high current conditions. The survey lasted 7 days. A total of 7019 red sea urchins were counted and 2651 were measured in 2797 quadrats on the 57 transects. Total transect length surveyed was 6328m for an average transect length of 111m.

Only 3 transects were surveyed in PFM sub-area 5-13, furthermore the three transects were all near the north-west end of the PFM sub-area. The density and biomass estimates obtained may therefore not be representative of the whole PFM sub-area which covers the northern third of Principe Channel on the east side of Banks Island.

In PFM sub-area 5-20, transects were surveyed in Larsen Harbour, the Borrowman Group and the mouth of Kingkown Inlet areas only. The portions of PFM sub-area 5-20 lying around Bonilla Island and south of the mouth of Kingkown Inlet were not selected for survey. Transects, however, were scattered through a large portion of the PFM sub-area so that the density and biomass estimates should be representative of the whole PFM sub-area.

The area at the mouth of Kingkown inlet was characterised by large areas of cobble and boulder substrate with a gentle slope so that large areas of urchin habitat were present. Kelp, mostly the canopy forming *Nereocystis luetkeana*, was abundant in the area.

SIZE FREQUENCY DISTRIBUTIONS

The overall mean size of red sea urchins measured was 90.0mm TD for all PFM sub-areas surveyed (Table 2, Figure 3). Mean size, on a PFM sub-area basis, ranged from 85.7 to 105.6mm TD. On a PFM sub-area basis, the smallest urchin measured ranged between 5mm TD and 11mm TD whereas the largest urchin measured ranged from 145mm TD to 183mm TD.

The overall percent of legal sized urchins (≥100mm TD) was 47.8% whereas the overall percent of urchins ≤50mm TD was 16.4%. On a PFM sub-area basis the percent of legal sized urchins ranged from 43.5% to 64.7% and the percent of urchins ≤50mm TD ranged from 10.3% to 21.0% (Table 2, Figure 4).

DENSITY AND BIOMASS ESTIMATES

The estimated mean density of urchins of all sizes was 2.23 urchins per m^2 (Table 3). The estimated mean density of legal sized urchins was 1.06 urchins per m^2. The estimated mean biomass of red sea urchins of all sizes was 743.9g per m^2 (Table 4). The estimated mean biomass of legal sized urchins was 580.0g per m^2.

On a PFM sub-area basis, density of urchins of all sizes ranged from 0.58 to 3.26 urchins per m^2 whereas density of legal sized urchins ranged from 0.23 to 1.54 urchins per m^2 (Table 3). Biomass of urchins of all sizes ranged, on a PFM sub-area basis, from 155.3 to 1068.6g per m^2 whereas biomass of legal sized urchins ranged from 116.9 to 826.7g per m^2 (Table 4).

DISCUSSION

Recruitment was defined as the percent of the total red sea urchin population that was ≤50mm TD. Red sea urchins populations often have low recruitment (Bernard 1977; Sloan et al. 1987), however, the size frequency distribution of red sea urchins from the current survey indicated relatively high recruitment (Figure 3). Recruitment ranged from 10.3% to 21.0% on a PFM sub-area basis and was 16.4% overall (Table 2). Recruitment was most pronounced in PFM sub-area 5-20 (Figure 4). The recruitment level observed on the current survey was the highest reported for the North Coast of BC. Recruitment levels from surveys conducted in 1994 in the North Coast of BC were 12.8% in the north-west Queen Charlotte Islands (Jamieson et al. 1998b) and 8.5% south of Bella Bella, central coast (Jamieson et al. 1998c).

Recruitment reported for southern BC was variable and ranged from 0 to 27% (Adkins et al. 1981; Breen et al. 1976; 1978; Sloan et al. 1987; Jamieson et al. 1998d). Recruitment levels observed here were within the range observed on the East Coast of Vancouver Island for surveys conducted in 1998 and 1999 (Bureau et al. 2000a; 2000b; 2000c). Recruitment was higher in the Comox region (22.2%) and lower in the Kelsey Bay (8.1%) and Gulf Island (3.1%) areas (Bureau et al. 2000a; 2000b; 2000c).

The percentage of legal sized urchins (≥100mm TD) in the present survey ranged from 43.5% to 64.7%, on a PFM sub-area basis, and averaged 47.8% overall and was relatively high for the North Coast of BC. Percent of urchins ≥100mm TD for surveys conducted in 1994 in the North Coast was 49.6% in the north-west Queen Charlotte Islands (Jamieson et al. 1998b) and 27.3% south of Bella Bella, central coast (Jamieson et al. 1998c). Percent of urchins ≥100mm TD, for surveys conducted in 1993, was 19.0% on the west side and 48.9% on the east side of the Queen Charlotte Islands, 26.3% in the southern portion of the central coast, 39.9% in the northern portion of the central coast and 50.4% for the Dundas Island region in the north coast (Jamieson et al. 1998a).

For the South Coast, Sloan et al. (1987) reported an average 76.0% of urchins were of legal size, for four areas in the Strait of Georgia, in 1985. In 1994, 52.7% of red sea urchins were of legal size in Queen Charlotte Strait and Broughton Strait, north-east Vancouver Island (Jamieson et al. 1998d). Surveys conducted in 1998 and 1999 reported proportions of legal sized urchins of 38.6% in the Comox region, 65.3% in Johnstone Strait and 87.1% for the Gulf Islands region (Bureau et al. 2000a; 2000b; 2000c).

The area covered by the current survey had not been surveyed before, therefore, no previous data were available for direct comparison of recruitment levels and proportions of legal sized urchins.

Density estimates from the current survey (2.23 urchins per m^2) were the highest reported from surveys conducted between 1997 and 1999. Surveys conducted in 1998 and 1999, using the same survey and analysis methods, showed red sea urchin densities (overall means per survey) of 0.59 urchins per m^2 in the Comox region, 1.27 urchins per m^2 in Johnstone Strait and 0.30 urchins per m^2 in the Gulf Islands (Bureau et al. 2000a; 2000b; 2000c).

Mean overall densities for surveys conducted in the North Coast in 1994 were 2.53 urchins per m^2 in the north-west Queen Charlotte Islands, 3.08 urchins per m^2 in the central coast and 1.11 urchins per m^2 in Queen Charlotte Strait and Broughton Strait (Jamieson et al.

1998b; 1998c; 1998d). Mean overall densities for surveys conducted in 1993 in the North Coast were calculated using data in Jamieson et al. (1998a). Mean overall density was 1.46 urchins per m^2 in the Queen Charlotte Islands (Haida survey), 0.41 urchins per m^2 in the lower central coast (Heiltsuk survey), 2.87 urchins per m^2 in the upper central coast (Kitasoo survey) and 1.18 urchins per m^2 in the north coast (Tsimshian survey).

Biomass estimates from the current survey (743.9g per m^2) were the highest reported from surveys conducted between 1997 and 1999. Surveys conducted in 1998 and 1999, using the same survey and analysis methods, showed red sea urchin biomass (overall means per survey) of 165.4g per m^2 in the Comox region, 524.4g per m^2 in Johnstone Strait and 199.1g per m^2 in the Gulf Islands (Bureau et al. 2000a; 2000b; 2000c). Surveys conducted in the North Coast in 1993 and 1994 reported red sea urchin densities but not biomass (Jamieson et al. 1998a; 1998b; 1998c; 1998d). The present survey was the first survey of the Northern Banks Island area, consequently, no earlier estimates of density and biomass were available for comparison.

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Table 1. Summary of transects surveyed during the 1997 red sea urchin (RSU) population survey in the Larsen Harbour and Kingkown Inlet areas, Banks Island. Transect lengths in m, density in number/m^2 and biomass in g/m^2. Num = Number, PFM = Pacific Fishery Management

Transect	PFM Sub-area	Latitude	Longitude	Transect Length	Number Quadrats	Num RSU Counted	RSU Density	RSU Biomass
1	5-13	53 37.598	130 26.179	101	51	82	1.61	541.3
2	5-13	53 37.914	130 26.969	129	65	1	0.02	5.9
3	5-13	53 38.077	130 27.458	163	82	35	0.43	265.8
4	5-11	53 38.130	130 28.510	22	6	0	0.00	0.0
5	5-11	53 38.245	130 29.078	103	52	23	0.44	179.3
6	5-11	53 37.908	130 29.996	260	20	0	0.00	0.0
8	5-11	53 38.290	130 31.380	340	79	111	1.41	358.9
9	5-11	53 37.906	130 32.035	180	30	0	0.00	0.0
10	5-20	53 37.930	130 33.327	5	3	70	23.33	5756.0
11	5-20	53 37.813	130 33.265	157	79	0	0.00	0.0
12	5-20	53 37.709	130 33.574	67	34	38	1.12	387.6
13	5-20	53 37.615	130 34.174	49	25	125	5.00	1934.5
14	5-20	53 37.190	130 33.805	245	123	107	0.87	347.7
15	5-20	53 37.131	130 34.201	171	86	195	2.27	730.8
16	5-20	53 37.519	130 34.821	39	20	0	0.00	0.0
17	5-20	53 37.114	130 34.771	47	24	144	6.00	2599.6
18	5-20	53 36.852	130 34.800	139	70	337	4.81	1646.0
19	5-20	53 36.734	130 34.812	91	46	99	2.15	719.0
20	5-20	53 36.384	130 34.711	57	29	59	2.03	453.2
21	5-20	53 37.127	130 35.667	9	5	32	6.40	3044.9
22	5-20	53 36.489	130 35.794	39	20	0	0.00	0.0
23	5-20	53 36.186	130 34.956	111	56	160	2.86	1016.8
24	5-20	53 36.019	130 35.372	93	47	128	2.72	1194.5
25	5-20	53 35.666	130 34.033	169	85	193	2.27	1037.2
26	5-20	53 34.215	130 35.525	197	99	161	1.63	647.2
27	5-20	53 34.877	130 32.858	139	70	240	3.43	1298.0
29	5-21	53 30.643	130 28.953	109	55	469	8.53	2260.6
30	5-21	53 30.852	130 28.564	167	84	297	3.54	924.0
31	5-21	53 30.456	130 28.712	59	30	72	2.40	552.1
32	5-21	53 30.473	130 27.678	135	68	124	1.82	802.5
33	5-21	53 30.082	130 27.940	183	92	305	3.32	1216.3
34	5-21	53 29.840	130 27.690	101	51	217	4.25	1604.6
35	5-21	53 29.727	130 27.211	254	6	0	0.00	0.0
36	5-21	53 29.556	130 27.505	155	78	370	4.74	1683.4
37	5-20	53 29.475	130 27.818	79	40	321	8.03	2617.3
38	5-20	53 29.341	130 27.936	45	23	149	6.48	1654.6
39	5-20	53 29.255	130 27.776	89	45	183	4.07	1070.1
40	5-21	53 28.888	130 26.874	117	59	237	4.02	1444.8
41	5-20	53 28.251	130 26.489	75	38	277	7.29	2022.9
42	5-21	53 28.980	130 25.010	77	39	37	0.95	621.2
43	5-21	53 29.222	130 25.888	119	60	80	1.33	352.2

Table 1 (cont'd)

Transect	PFM Sub-area	Latitude	Longitude	Transect Length	Number Quadrats	Num RSU Counted	RSU Density	RSU Biomass
44	5-21	53 28.408	130 25.235	389	195	429	2.20	710.8
45	5-21	53 28.350	130 24.949	35	18	101	5.61	2243.8
46	5-21	53 28.059	130 25.487	25	13	69	5.31	1428.5
47	5-20	53 27.738	130 24.983	41	21	143	6.81	1811.8
48	5-20	53 27.607	130 24.809	113	57	591	10.37	2500.2
49	5-21	53 30.226	130 26.289	29	15	1	0.07	59.8
50	5-21	53 29.985	130 26.009	105	53	173	3.26	1611.4
51	5-21	53 29.984	130 25.042	69	35	0	0.00	0.0
52	5-21	53 29.918	130 24.749	101	51	0	0.00	0.0
53	5-21	53 30.514	130 24.189	119	60	34	0.57	325.5
54	5-21	53 30.136	130 23.737	27	14	0	0.00	0.0
55	5-21	53 30.007	130 23.582	11	6	0	0.00	0.0
57	5-21	53 30.808	130 23.421	157	79	0	0.00	0.0
58	5-21	53 31.061	130 22.993	185	93	0	0.00	0.0
59	5-21	53 31.257	130 22.605	21	11	0	0.00	0.0
60	5-21	53 31.048	130 22.239	15	8	0	0.00	0.0

Table 2. Number of red sea urchins measured and percent (in brackets) of total urchins ≤50mm TD and ≥100mm TD for each Pacific Fishery Management (PFM) sub-area surveyed in the 1997 population survey in the Larsen Harbour and Kingkown Inlet areas, Banks Island.

PFM	Size Measured (mm)			Numbers Measured		
Sub-area	Minimum	Maximum	Mean	Total	≤50mm TD	≥100mm TD
5-11	11	145	85.7	62	13 (21.0)	27 (43.5)
5-13	11	169	105.6	68	7 (10.3)	44 (64.7)
5-20	5	183	88.1	1416	259 (18.3)	656 (46.3)
5-21	6	168	91.8	1105	156 (14.1)	540 (48.9)
5 Total	5	183	90.0	2651	435 (16.4)	1267 (47.8)

Table 3. Estimates of density of red sea urchins (RSU), by Pacific Fishery Management (PFM) sub-area, for the 1997 survey in the Larsen Harbour and Kingkown Inlet areas, Banks Island.

PFM Sub-Area	Number of Transects	Sum of Transect Lengths (m)	Est. Number of RSU on Transects		Mean Density RSU/m^2		Standard Error of Mean Density	
			All Sizes	≥100mm	All Sizes	≥100mm	All Sizes	≥100mm
5-11	5	905	523	208	0.58	0.23	0.41	0.16
5-13	3	393	234	134	0.60	0.34	-	-
5-20	24	2,266	7,394	3,480	3.26	1.54	0.61	0.25
5-21	25	2,764	5,978	2,915	2.16	1.05	0.46	0.22
5 Total	57	6,328	14,129	6,736	2.23	1.06	0.33	0.15

Table 4. Estimates of biomass per m^2 of red sea urchins (RSU), by Pacific Fishery Management (PFM) sub-area, for the 1997 survey in the Larsen Harbour and Kingkown Inlet areas, Banks Island.

PFM Sub-Area	Number of Transects	Sum of Transect Lengths (m)	Est. Weight of RSU on Transects (kg)		Mean Biomass of RSU g/m^2		Standard Error of Mean Biomass	
			All Sizes	≥100mm	All Sizes	≥100mm	All Sizes	≥100mm
5-11	5	905	140.5	105.8	155.3	116.9	105.0	76.5
5-13	3	393	98.8	83.3	251.3	212.0	-	-
5-20	24	2,266	2,421.4	1,873.2	1068.6	826.7	169.1	122.4
5-21	25	2,764	2,046.4	1,607.7	740.3	581.6	150.1	121.1
5 Total	57	6328	4,707.1	3,670.0	743.9	580.0	100.4	78.0

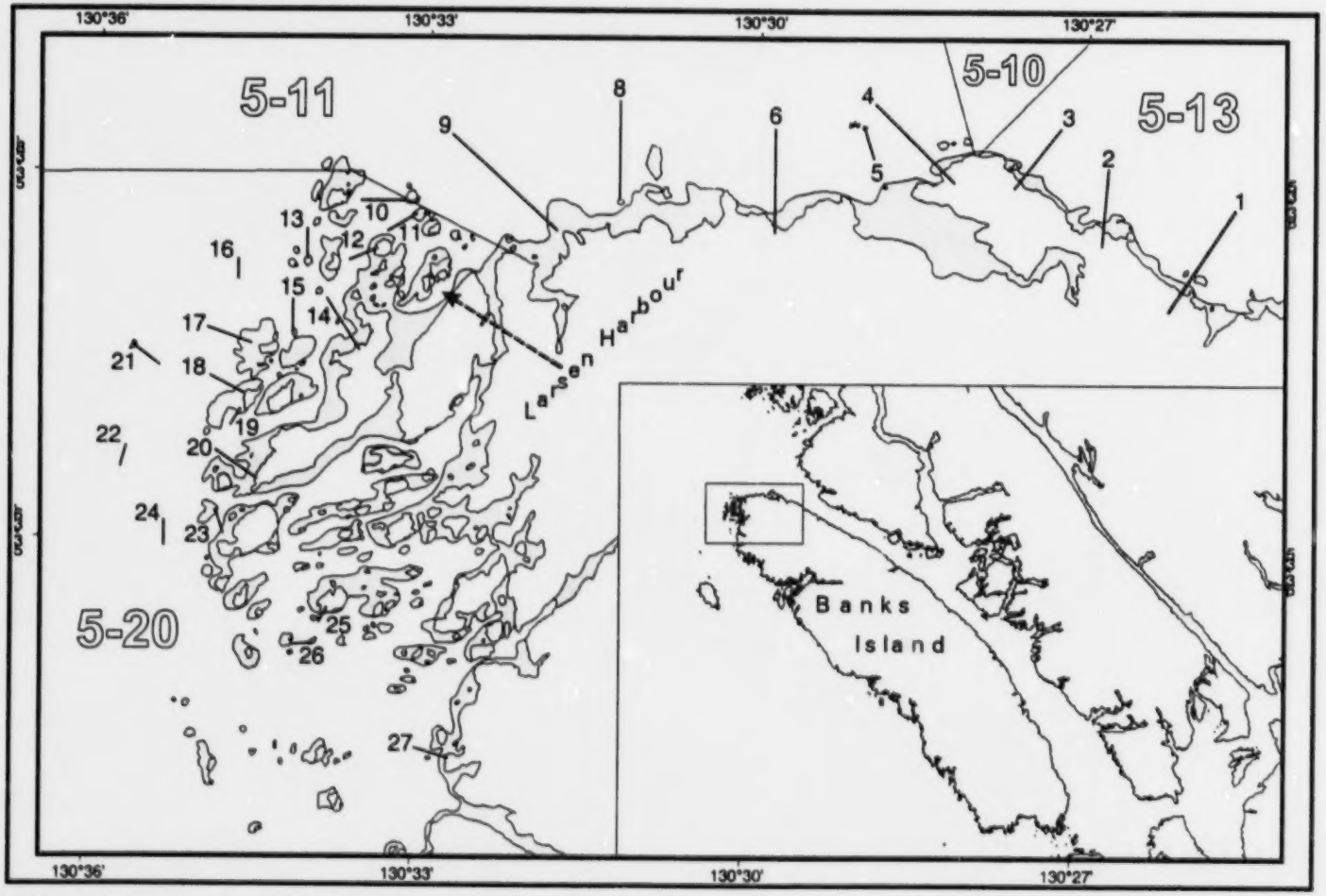

Figure 1. Map of survey area and transect locations for the Larsen Harbour section of the 1997 red sea urchin population survey at Banks Island. Outlined numbers indicate Pacific Fishery Management sub-areas and solid numbers identify transects. Light grey areas represent land and dark grey areas represent the intertidal zone.

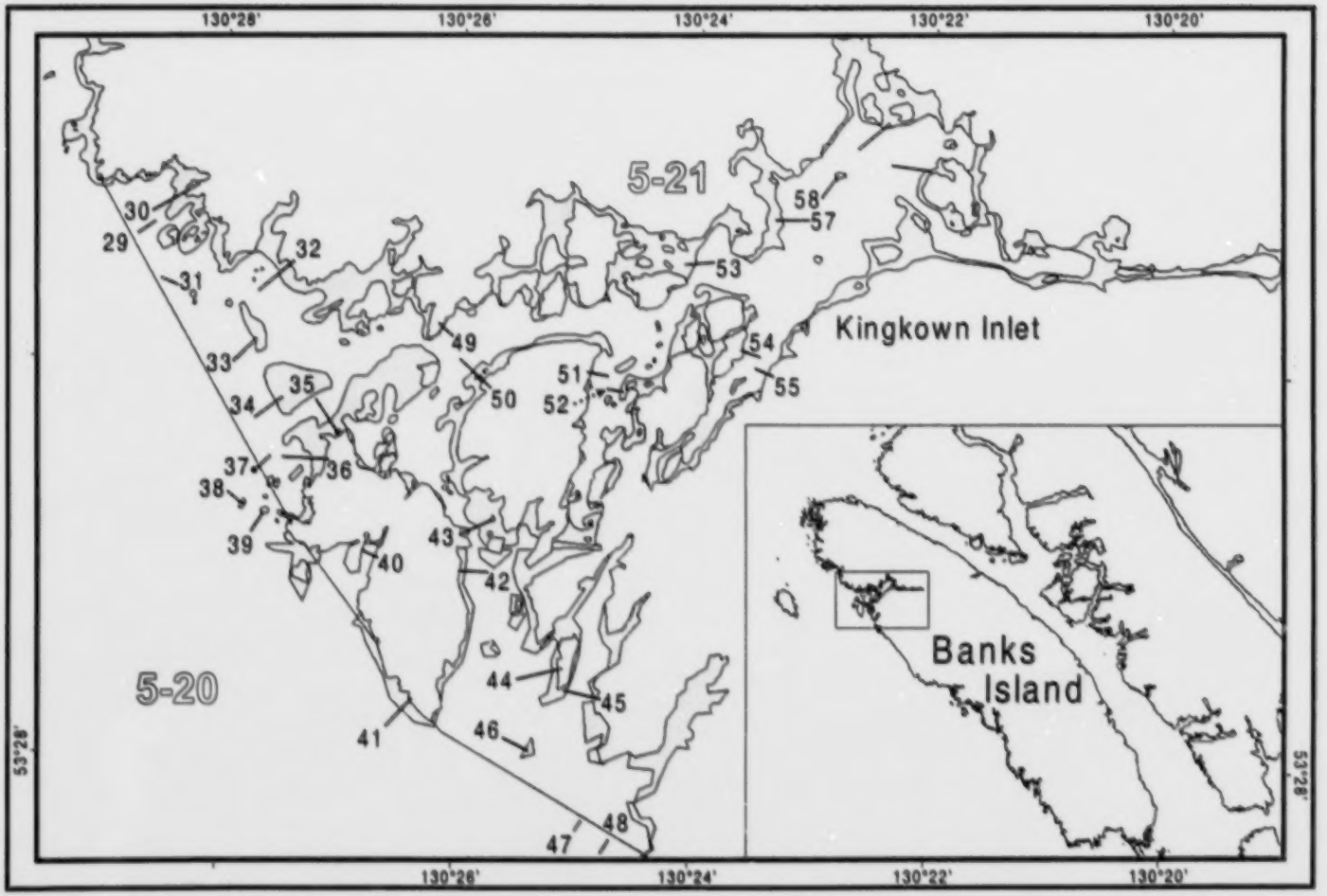

Figure 2. Map of survey area and transect locations for the Kingkown Inlet portion of the 1997 red sea urchin population survey at Banks Island. Outlined numbers indicate Pacific Fishery Management sub-areas and solid numbers identify transects. Light grey areas represent land and dark grey areas represent the intertidal zone.

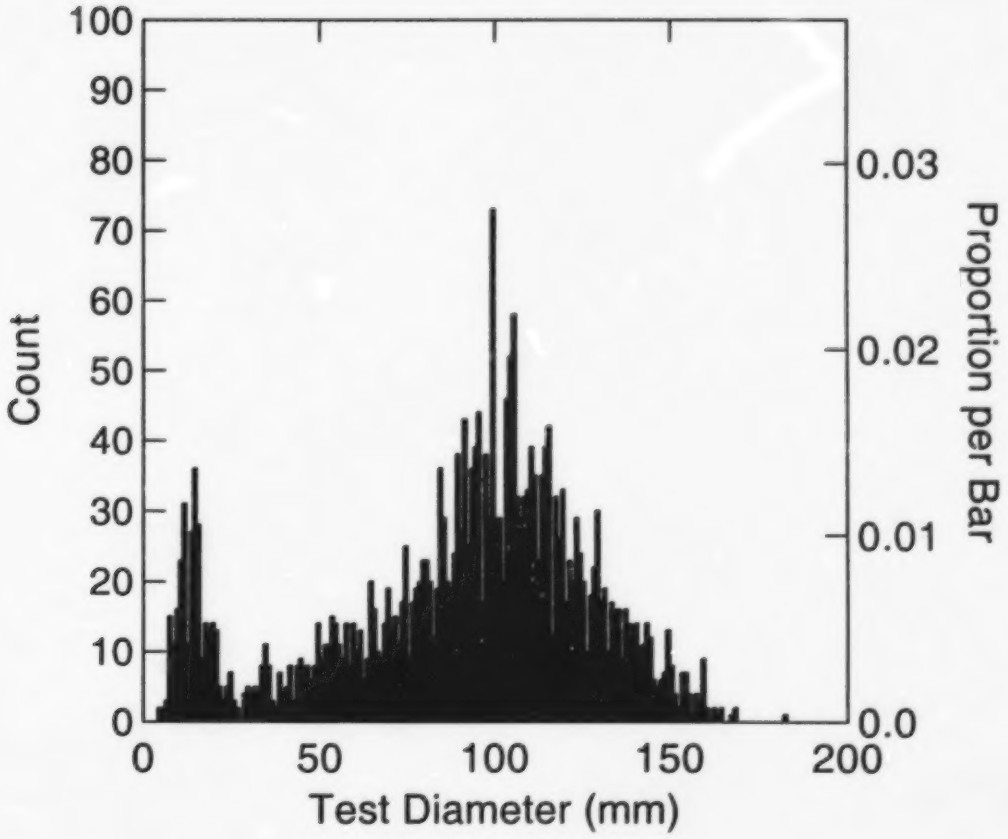

Figure 3. Size frequency distribution of red sea urchins measured on all transects during the 1997 survey in the Larsen Harbour and Kingkown Inlet areas, Banks Island (n=2651).

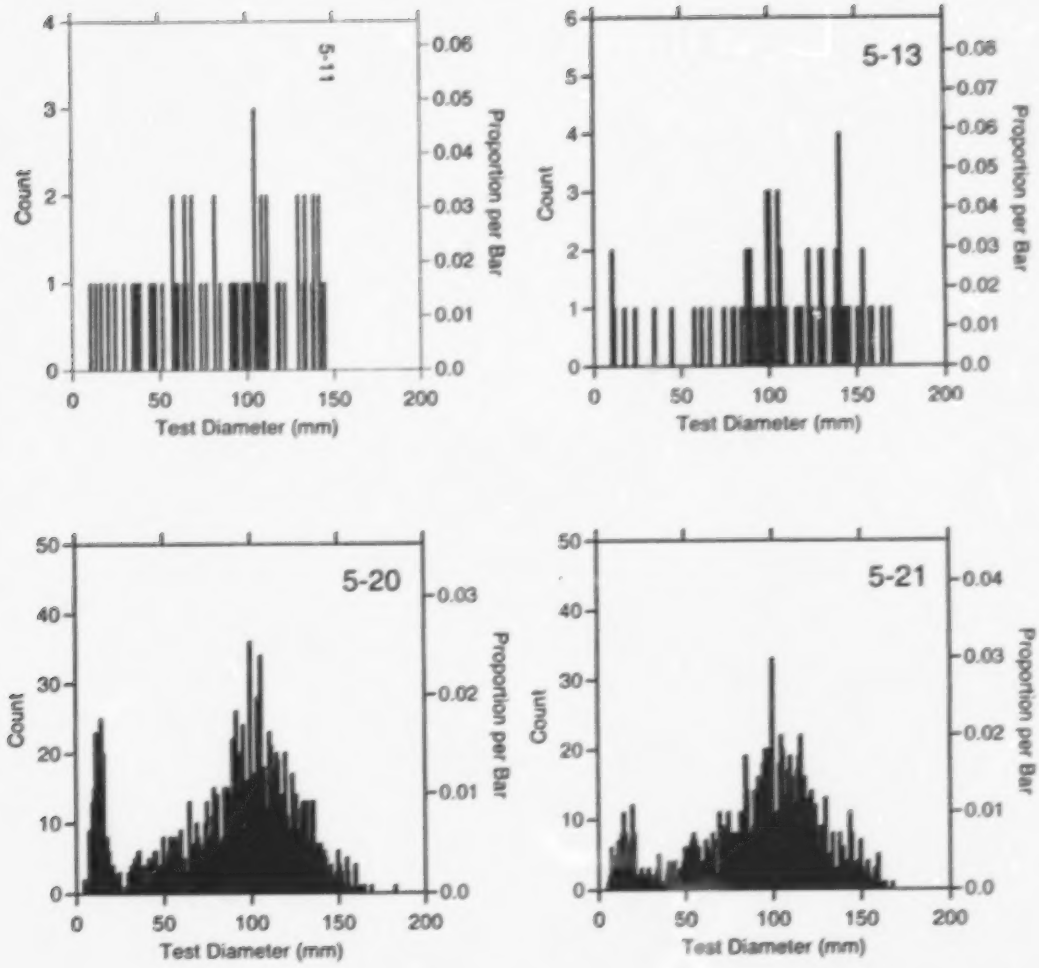

Figure 4. Size frequency distributions, per Pacific Fishery Management (PFM) sub-area, of red sea urchins measured during the 1997 survey in the Larsen Harbour and Kingkown Inlet areas, Banks Island. The numbers in the upper right hand side of graphs are the PFM sub-area numbers.